ONE ACRE FUND

Managing Soil Acidity

2014 Phase 2 Trial Report

Kelvin Owino/One Acre Fund.

Background

Due to climate and geology, African soils can be relatively acidic and the vast majority of smallholder farmers in East Africa cultivate acidic soils. The severity of the acidity is variable, but the Kenyan Ministry of Agriculture estimates that around 50 percent of smallholders in western Kenya may be farming soils with pH below 5.5 (optimum pH for plant growth is 6.5). Soil acidity is important for several reasons:

- At low soil pH (more acidic), nutrients abundant in the soil become unavailable for plants to utilize. This frequently results in plant nutrient deficiencies and poor yields.
- The plant availability of fertilizer nutrients is also diminished, resulting in low fertilizer use efficiency (more fertilizer is needed to get the same level or harvest) and reduced farmer profit and food security.
- Some elements in the soil (aluminum) can become toxic.

Soil acidity must be addressed for farmers to receive the greatest benefits from their investments in seed and fertilizer

I. Results Summary

- **Current acidity management:** Currently, One Acre Fund does not distribute agricultural lime. However, by recommending practices like fertilizer microdosing and compost use, we hope to slow the rate of soil acidification on smallholder farms.
- **Primary product configuration tested:** One Acre Fund trialed different agricultural lime quantities and application methods with 295 farmers in 2014. These included 1) broadcast application at 2.0 tonnes/hectare (t/ha); 2) banded application at 1.0 t/ha and 3) spot application at 0.5 t/ha.
- **Potential value of intervention:** Yield improvements ranged from 14-25 percent, corresponding with profit increases of $291-$741 USD per hectare. At 100 percent program adoption, this would mean an additional 24,000 tonnes of maize produced by smallholders in western Kenya and an additional $28 million USD in generated revenue.
- **2015 trials:** We believe it is possible to improve average maize yields to over 5 t/ha with the use of lime for soil acidity management. We offered lime at the district level (10,000+ farmers) and intend to evaluate a potential programmatic inclusion of lime. We also intend to reevaluate the impact of lime in different locations to better understand yield responses as a function of starting pH.

II. Product Rationale and Approach

- **Rationale:** We currently train farmers on various practices that can reduce the rate of soil acidification such as efficient fertilizer use, composing, and mulching. However, we do not do

anything that reverses soil acidification. By offering lime in conjunction with trainings on practices that reduce acidification rates we can help farmers better manage soil acidity.

- **Our approach:** One major constraint to lime use is the quantity required. In most cases lime use is recommended in the order of tons per hectare while other inputs, like seed and fertilizer, are measured in kilograms (kg) per hectare. We intended to evaluate the efficacy of smaller quantities of lime (500kg – 2.0 t/ha) and different application methods (spot and banded applications) that may increase the efficiency of these smaller lime quantities.
- **Product selection criteria:** These trial configurations were chosen based on the four criteria of impact (incremental dollar income added to the farmer), adoption (farmer demand), complexity (ability to realize return) and operability (scale potential). We also considered long-term impact for soil and environmental health.

III. Partners Consulted

We worked with a number of experts to better understand the science of soil pH changes and consider ways to modify common lime application practice to suit the smallholder context:

- **IPNI** – Consultations on the likely effects of lower application rates of lime
- **IFDC** – Consultations on crop responses to lime in the East African context
- **AGRA –** Consultation on potential alternative lime application methods
- **Home Lime –** Supply of calcium oxide lime for trials
- **CNLS** – Soil sampling at the beginning and end of the lime trial

These organizations were extremely helpful, and were excited to see their research and products being put into farmers' hands.

IV. Trials Summary (Phases 0-2)

One Acre Fund tested improved maize fertilizer with a standardized trial phase process as summarized below.

Soil pH for the healthy soybean plants in the background was 5.6. The poor soybeans in the foreground were growing in a soil pH of 4.3. David Guerena/ One Acre Fund.

	Trial Phase			
	0	**1**	**2**	**3**
# Farmers	0	0	295	434[1]
Yield Impact	N/A	N/A	14 – 25%[2]	N/A
Profit Impact / Ha[3]	N/A	N/A	$291 – $741	N/A
Adoption Level	N/A	N/A	92%[4]	3%[5]
Key Activities / Configurations	**Preliminary Research** 1. Desk research 2. Consultation with experts 3. Visiting 3rd party trials	**Research station trials:** N/A	**Farmer level trials:** 1. Broadcast + High Rate 2. Banded + Medium Rate 3. Spot + Low Rate	**2015 district offering:** 1. 1/8 acre lime package
Testing Priorities	• Research potential easy, high impact soil acidity management interventions.	N/A	• Evaluate impact, complexity, and operability at a larger scale of promising lime interventions	• Determine existing demand for lime through purchase rates at the district level.

[1] 2015 enrollment, subject to change due to possible farmer drops
[2] Range of the yield impacts of the noted phase 2 configurations.
[3] Highest measured single configuration profit impact
[4] Farmers did not purchase, but 92% expressed that they would purchase next season if offered.
[5] Offered in Webuye district only

Trial Name	Hypothesis	Treatments	Controls
Traditional Application	Lime is a widely used agricultural input for correcting soil acidity. By applying lime using traditionally acknowledged best practices we expect to see a strong yield response.	OAF core program + 2.0 t/ha CaO two months before planting evenly applied across the field.	OAF core program
Reduced Quantity + Banding	Reducing the amount of lime used increases potential adoptability. However it requires more precise use of applied lime. Therefore, applying only to the lines where plants will be growing will be more efficient than broadcast application.	OAF core program + 1.0 t/ha CaO two months before planting applied to marked planting rows.	OAF core program
Microdosed Lime	Very small quantities of lime can still be effective, even when applied at planting, if extreme precision is employed through spot application of lime at each planting station.	OAF core program + 0.5 t/ha Cao applied at the time of planting.	OAF core program

V. Trial Results

Improved maize fertilizer farmer trials also took place in western Kenya in Bungoma County, south of Bungoma town. The average growing conditions are as follows:

Altitude	Rainfall	pH	SOM	N	P	K	Ca	Mg
1,310 m	1,088 mm	5.24	3.81%	0.15%	8.28 ppm	101 ppm	733 ppm	129 ppm

Latitude: 0.54964828859571 **Longitude:** 34.457568475713

Traditional Application: Trial Overview

Hypothesis

Lime is an agricultural input widely used for correcting soil acidity. By applying lime using traditionally acknowledged best practices, we expect to see a strong yield response.

Summary

We sought to evaluate the potential impact of lime application under standard practice conditions. Through consultation with experts in the field we determined a quantity of lime likely to produce a strong yield response. In addition to quantity we targeted the most appropriate lime application method. By broadcasting lime evenly over the field two months prior to planting we intended to allow sufficient time for initial pH changes in the soil to occur. As the soil acidity neutralization capacity of lime takes weeks to months an early application, it was believed, would further increase the likely yield response.

Impact

Given the degree of acidity measured in our Bungoma South trial district we expected to see a substantial yield and profitability increase from best practice lime application. This was confirmed in results, showing that a fairly moderate 2.0 t/ha application of lime produced a 25% yield increase, on average.

	Configuration	Location / Date	Yield (t/ha)	Profit (USD/ha)	Profit Change vs. Trial Control
1. Control: Variety WE1101, 124kg/ha DAP, 124kg/ha CAN, 53,000 plants/ha	120 farmers	Western Kenya, LR 2014	7.4	$2,759	$0
2. Broadcast lime: Variety WE1101, 124kg/ha DAP, 124kg/ha CAN, 53,000 plants/ha + 2.0 t/ha CaO broadcast	120 farmers	Western Kenya, LR 2014	9.2	$3.500	+$741

This trial took place in a particular site within our Bungoma South trial district. Farmers in this site experienced very high baseline yields. However, even with these higher-than-normal baselines, they still experienced 25 percent yield increases.

Adoptability

Cost: At a cost of $60 USD per tonne, a 0.2 hectare application of lime at 2.0 t/ha would cost a farmer $24 USD. This is not insubstantial, as the average One Acre Fund package price for 2015 is about $100. There is a clear profit opportunity to be seen, however a 24 percent addition to the cost of inputs for a farmer may be prohibitive. Applying lime as broadcast at this rate is also a significant labor commitment.

Complexity: Of the lime application configurations that were trialed, the traditional application was the simplest in practice. Farmers apply lime to the whole field and incorporate the lime with a hand hoe. While this is a significant labor requirement, it is fairly straightforward.

Preference: Lime is an entirely new product for many farmers and many are not accustomed to using it. Initial adoption numbers when sold were low at 3 percent, suggesting a potential lack of awareness of the product and its benefits.

Operability

Sourcing: Homa Lime is an established local lime supplier located in Nyanza. However, it is unclear if they will be able to supply their product at a larger scale. There are other potential suppliers such as Athi River Mining (ARM) outside of Nairobi, but the cost per ton from ARM is higher, largely attributable to greater transport distance.

Distribution: Lime would be among the bulkiest products that One Acre Fund has offered. At the 2.0 t/ha application rate, our standard 0.2 hectare package would require 400kg of lime. Currently, the combined weight of seed and fertilizer offered as part of the core 0.2 hectare package is 55kg. Inclusion of lime at this rate increases the amount of material distributed to each farmer eight-fold. A two-month lead time may actually require lime distribution take place prior to completion of One Acre Fund's pre-payment period.

Training Complexity: As a new product, farmer trainings on proper lime use may be difficult. Logistically the broadcast application method means starting the season two months earlier than typical resulting in pre-season trainings.

Next Steps

- While traditional application produced the largest yield and profit increases, the cost and quantity make it difficult to adopt and distribute.
- This configuration will not be repeated in 2015. Focus will be on identifying more adoptable and operable lime interventions.

Reduced Quantity + Banding: Trial Overview

Hypothesis

Reducing the amount of lime used increases potential adoptability. However, it requires more precise use of applied lime. Applying only to the lines where plants will be growing will be more efficient than broadcast application.

Summary

We sought to evaluate the potential impact of lime application at a reduced application rate, compensated by a more precise application method. All variables were kept the same as the traditional method (i.e. lime type and pre-planting application timing) except that the rate was reduced to 50 percent and only applied to the bands of soil in which the maize would be planted. Lime was applied two months prior to planting and the lime application bands (at 75cm spacing per future maize row spacing) were marked with sticks. Maize was planted on these bands two months later.

Impact

Combining a reduced lime quantity with higher precision application did not result in the same yield improvements that were measured resulting from traditional lime application. However, an 18% yield improvement was measured.

	Configuration	Location / Date	Yield (t/ha)	Profit (USD/ha)	Profit Change vs. Trial Control
1. Control: Variety WE1101, 124kg/ha DAP, 124kg/ha CAN, 53,000 plants/ha	91 farmers	Western Kenya, LR 2014	4.0	$1,413	$0
2. Banded lime: Variety WE1101, 124kg/ha DAP, 124kg/ha CAN, 53,000 plants/ha + 1.0 t/ha CaO banded	91 farmers	Western Kenya, LR 2014	4.7	$1,704	+$291

The two-month advance banded application of lime may have resulted in diluted, rather than precise, application. It is unclear to what extent prevailing weather conditions such as rainfall and wind may have influenced the location of the area affected by the lime application. If this was the case, the degree of the liming effect may have been reduced.

Adoptability

Cost: At a cost of $60 USD per tonne, a 0.2 hectare application of lime at 1 t/ha would cost a farmer $12 USD. This is not insubstantial, as the average One Acre fund package price for 2015 is about $100. However, there is a clear advantage to applying at this rate over traditional application methods from an absolute cost standpoint. Labor is reduced as well when considering the halving of the amount of lime applied to the field.

Complexity: The banded application method was the most complex of the lime configurations that were trialed. Farmers have to be sure that the rows of maize are planted in line with the lime application from two months prior.

Preference: Lime is an entirely new product for many farmers and many are not accustomed to using it. Initial adoption numbers when sold were low at 3 percent, suggesting a potential lack of awareness of the product and its benefits.

Operability

Sourcing: Homa Lime is an established local lime supplier located in Nyanza. However, it is unclear if they will be able to supply their product at a larger scale. There are other potential suppliers such as Athi River Mining (ARM) outside of Nairobi, but the cost per ton from ARM is higher, largely attributable to greater transport distance.

Distribution: Lime would be among the bulkiest products that One Acre Fund has offered. At the 1.0 t/ha application rate, our standard 0.2 hectare package would require 200kg of lime. Currently, the combined weight of seed and fertilizer offered as part of the core 0.2 hectare package is 55kg. Inclusion of lime at this rate increases the amount of material distributed to each farmer four-fold. A two-month lead time may actually require lime distribution take place prior to completion of One Acre Fund's pre-payment period.

Training Complexity: As a new product, farmer trainings on proper lime use may be difficult. Logistically the banded application method means starting the season two months earlier than is typical, and would require pre-season trainings.

Next Steps

- This configuration will not be repeated in 2015. Focus will be on identifying more adoptable and operable lime interventions.

Microdosed Lime: Trial Overview

Hypothesis

Very small quantities of lime can still be effective, even when applied at planting, if extreme precision is employed through spot application of lime at each planting station.

Summary

Microdosing is a technique currently used by One Acre Fund farmers to efficiently apply small amounts of fertilizer at each planting station. We reduced the per-hectare lime application rate to 25 percent of the traditional application amount, or 0.5 t/ha. Because spot application two months prior to planting would be too complicated to match to planting stations, farmers applied lime at the time of planting rather than two months prior, as was the case for the other two trialed lime configurations. Farmers applied a cup of lime to the soil beneath the placement of fertilizer and seed.

Impact

Even though the lime application rate was reduced to 25 percent of the traditional method, the yield impact remained high at 14 percent, which was 56 percent of the yield improvement achieved through traditional application methodology and rate.

	Configuration	Location / Date	Yield (t/ha)	Profit (USD/ha)	Profit Change vs. Trial Control
1. Farmer control: Variety WE1101, 124kg/ha DAP, 124kg/ha CAN, 53,000 plants/ha	84 Farmers	Western Kenya, LR 2014	6.6	$2,433	$0

2. Spot lime: Variety WE1101, 124kg/ha DAP, 124kg/ha CAN, 53,000 plants/ha + 0.5 t/ha CaO spot applied	84 Farmers	Western Kenya, LR 2014	7.5	$2,806	$373

This configuration appears to have proven that, in this context, the two-month application lead time, while chemically effective, is not necessary to see a first season yield result. This is a promising result from both an adoptability and operability point of view.

Adoptability

Cost: This lime configuration produced 50 percent of the profit gain achieved by traditional application at 25 percent of the upfront cost. At a cost of $60 per tonne a 0.2 hectare application of lime at this rate would cost a farmer $6 USD. This cost is much more manageable to a One Acre Fund farmer whose average package expense is $100. Labor is reduced as well when considering the 75 percent reduction in lime quantity and the fact that it can be applied during the same pass as planting.

Complexity: This application method is more complex than the traditional broadcast approach, but given that One Acre Fund farmers are trained within the context of microdosing and approaching each plant one at a time, there is an existing framework in place to reduce the complexity of the process.

Preference: Lime is an entirely new product for many farmers and many are not accustomed to using it. Initial adoption numbers when sold were low at 3 percent, suggesting a potential lack of awareness of the product and its benefits. However, the package offered was at a higher cost-per-unit land area. This configuration may be more attractive to farmers.

Operability

Sourcing: Homa Lime is an established local lime supplier located in Nyanza. However, it is unclear if they will be able to supply their product at a larger scale. There are other potential suppliers such as Athi River Mining (ARM) outside of Nairobi, but the cost per ton from ARM is higher, largely attributable to greater transport distance.

Distribution: Lime would be among the bulkiest products that One Acre Fund has offered. At the 0.5 t/ha application rate, our standard 0.2 hectare package would require 100kg of lime. Currently, the combined weight of seed and fertilizer offered as part of the core 0.2 hectare package is 55kg. Inclusion of lime at this rate increases the amount of material distributed to each farmer two-fold. This amount is much more manageable than the other proposed configurations, but an obstacle nevertheless.

Training Complexity: As a new product, farmer trainings on proper lime use may be difficult. However, the fact that this approach trains farmers on lime application during planting rather than two months before makes it easier to promote. Additionally, this approach works within the existing One Acre Fund microdosing framework.

Next Steps

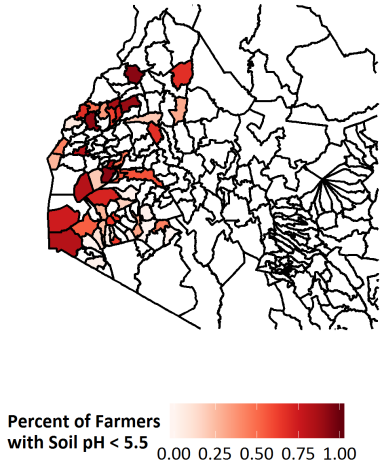
- Microdosed application of lime will be re-trialed and reconfigured into new trials in the 2015 season for over 700 farmers in our Bungoma South district.
- Microdosed application rates lower than 0.5 t/ha will be trialed.
- Combination of microdosed lime and alternative fertilizers (such as a custom-blend planting fertilizer and urea topdress) will be evaluated.

VI. Conclusions and Next Steps

Soil acidity is a widespread problem in East Africa, and one that requires a holistic approach. Lime is an effective way to correct soil pH when it becomes damagingly low, however, practices to slow the rate of acidification must be adopted as well. These include:

- Precision use and application of mineral fertilizer
- Applying mulch to reduce weathering
- Applying compost to increase soil organic matter levels and reduce the rate of leaching

Promising Sub-Counties for Lime Intervention



The benefit of lime application will vary by location and farming system and is a function of a number of environmental and economic variables. The above map identifies sub-counties in western Kenya where the prevalence of severe acidity (defined as pH below 5.5) is high and strongly limiting yields.

a. Yield and Profit

- The potential yield gains associated with lime use have been measured to be at least 14 percent at only 0.5 t/ha. At 100 percent program adoption, this would mean an additional 24,000 tonnes of maize produced by smallholders in western Kenya and an additional $28M in generated revenue.
- It is important to consider that the yield response to lime may vary from by location, but this is also something that applies to yield responses to improved seed, fertilizer, and various agronomic practices.
- We intend to be comprehensive with our evaluation of the appropriateness of distributing lime to a client. If a switch away from Calcium Ammonium Nitrate (CAN) as a topdress fertilizer in favor of urea is to happen, seasonal lime application would be prudent for all farmers as a hedge to the acidifying effect of this fertilizer.

b. Farmer Adoption

- Nearly every farmer within the One Acre Fund program grows maize and works with acidic soil. However, a non-compulsory offering of lime may require interventions to boost adoption.
- The small plot lime option (0.05 hectares) was only adopted at a 3 percent rate in Webuye district. As very little marketing of lime was done in this season, we used this opportunity to evaluate natural demand.
- We need to decide whether lime should be bundled in to the core package in some areas deemed to be high acidity risk / high potential impact.

c. Operability at Scale

- We have a few different potential lime suppliers; however Homa Lime has proven to be the lowest cost option. If they are unable to meet our scale demands, the cost of distributing lime may increase significantly.
- Operability of these configurations at scale would require the following:
    - Distributing over 18,000 tonnes of lime assuming a 0.2 hectare package and microdosed application.
    - Design and production of 150,000 standard sized lime application cups
    - Writing of new trainings and the training of over 800 field officers.
    - Potential addition of hundreds of distribution trucks.

d. Next Steps

In 2015, One Acre Fund will:

- Distribute lime and lime trainings to 434 farmers in Webuye district in western Kenya.
- Trial reconfigurations of the products and practices contained within this report with over 700 farmers:
    - Maize urea topdress + lime at 0.5 t/ha
    - Maize urea topdress + lime at 0.25 t/ha
    - Maize urea topdress + lime at 0.125 t/ha
    - Microdosed lime application at 0.5 t/ha
    - Microdosed lime application at 0.25 t/ha
    - Microdosed lime application at 0.125 t/ha
    - Microdosed lime at 0.5 t/ha + custom blend planting fertilizer + urea topdress
- Research additional approaches to soil acidity management to ensure a holistic approach is being taken.

- Analyze the results of 2,400 geo-referenced soil samples taken from Rwandan and Kenyan areas of operation in conjunction with yield measurements to better understand pH limitations in maize and other crops.